EFFECT OF DIFFERENT BUILD ORIENTATION ON MECHANICAL PROPERTIES OF FIBERGLASS REINFORCED COMPOSITE

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT’S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurently submitted for award of other degree.

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To my beloved father and mother

Mr.Muhamad Atan Bin Awang
Mrs Juhani Binti Othman

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ABSTRACT

This thesis deals with effect of different build orientation on mechanical properties of fibreglass reinforced composite. The objective of this thesis is to investigate the mechanical properties of fibreglass reinforced composite with different build orientation, investigate the relation between fibreglass and polyester resin, and to understand on the mechanical behaviour of fibreglass reinforced composite. Fibreglass is refer to a group of products made from individual glass fibres combined into a variety of forms and act as reinforcing agent. The problem of bonding between fibreglass and the matrix resin affect the strength of the fibreglass reinforced composite and this need to be deals with the study on their mechanical properties by using mechanical experiment test. The test is carried out using tensile test, which all are focusing on investigating mechanical properties on the specimens. Fibreglass reinforced composite is made up by using hand lay-up technique, where different laminate of fibreglass made up by different build orientation of fibreglass which result different strength. The aim of the test is to study on this fibreglass reinforced composite strength and to observed on the mechanical behaviour of this material. It was found that by arranging the fibreglass properly, the stronger the fibreglass reinforced composite be.

ABSTRAK

Tesis ini membentangkan kesan daripada berlainan orientasi binaan kepada fiber-reinforced plastic (FRP). Objektif tesis ini ialah untuk mengkaji sifat mekanikal FRP dengan berlainan orientasi bahan gentian kaca, menyiasat hubung kait antara bahan gentian kaca dengan bahan penguat, serta memahami sifat laku mekanikal bahan tersebut. Plastik yang diperkukuh, atau dikenali sebagai FRP ini mempunyai bahan gentian kaca didalamnya. Masalah yang timbul di antara ikatan gentian kaca dan bahan penguat resin menjejaskan kekuatan bahan ini, dan tesis ini membincangkan sifat mekanikal bahan ini dengan cara menjalankan eksperimen. Eksperimen yang dijalankan iaitu, 'tensile test' memfokuskan kajian tentang sifat-sifat mekanikal yang ditunjukkan oleh specimen. FRP ini dihasilkan sendiri menggunakan tangan melalui teknik 'tindih dan tindih', yang mana orientasi bahan gentian kaca yang berbeza, akhirnya mempunyai kekuatan berlainan. Tujuan dijalankan eksperimen ini ialah bagi mengukur kekuatan bahan dan melihat sendiri perubahan yang berlaku terhadap FRP ini apabila dikenakan daya. Ianya diketahui bahawa menyusun bahan gentian kaca dengan betul, maka makin kuat bahan tersebut.

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LIST OF SYMBOLS

σ	Engineering Stress
ε	Engineering strain
δ	Change in the specimen's gage length
L_o	Original gage length
σ_{ut}	Ultimate Tensile Strength
σ_y	Yield Stress
°C	Degree Celcius
ºF	Degree Fahrenheit
mm	millimeter
MPa	Mega Pascal
%	percentage
kN	Kilonewton
P	Applied Load
A_O	Original cross sectional area
E	Young's Modulus

LIST OF ABBREVIATIONS

GFRP	Glass Fiber Reinforced Polymer
PMCs	Polymer Matrix Composites
CFRP	Carbon Fiber Reinforced Polymer
ASTM	American Society for Testing and Materials
FRP	Fiber Reinforced Plastic
GRE	Glass Fibre Reinforced Epoxy
R&D	Research and Development
RF	Radio Frequency
UTS	Ultimate Tensile Strength
PVC	Polyvinyl Chloride
PE	Polyethylene
PP	Polypropylene
UP	Unsaturated Polyester
PURs	Polyurethenas

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The term composite could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail. But in modern materials engineering, the term usually refers to a “matrix" material that is reinforced with fibres. For instance, the term “FRP" (for Fibre Reinforced Plastic) usually indicates a thermosetting polyester matrix containing glass fibres, and this particular composite has the lion's share of today's commercial market.

Many composites used today are at the leading edge of materials technology, with performance and costs appropriate to ultra demanding applications such as spacecraft. But heterogeneous materials combining the best aspects of dissimilar constituents have been used by nature for millions of years. Ancient society, imitating nature, used this approach as well: the Book of Exodus speaks of using straw to reinforce mud in brick making, without which the bricks would have almost no strength. The fibres used in modern composites have strengths and stiffness far above those of traditional bulk materials. The high strengths of the glass fibres are due to processing that avoids the internal or surface flaws which normally weaken glass, and the strength and stiffness of the polymeric aramid fibre is a consequence of the nearly perfect alignment of the molecular chains with the fibre axis. Of course, these materials are not generally usable as fibres alone, and typically they are impregnated by a matrix material that acts to transfer loads to the fibres, and also to protect the fibres from abrasion and environmental attack. The matrix dilutes the properties to some degree, but even so very high specific (weight-adjusted) properties are available from these materials. Metal and glass are available as matrix materials, but these are currently very expensive and largely restricted to R&D laboratories. Polymers are much more commonly used, with unsaturated styrene-hardened polyesters having the majority of low-to-medium performance applications and epoxy or more sophisticated thermosets having the higher end of the market.

1.2 OBJECTIVES OF STUDY

i. To investigate the mechanical properties of fibreglass reinforced composite with different build orientation.

ii. To determine the mechanical strength (tensile strength) of fibreglass reinforced composite.

1.3 SCOPES OF PROJECT

i. To prepare the sample specimen based on different orientation of fibreglass which are 0°, 90° and random.

ii. To examine the strength of the specimen by tensile test method using Universal Testing Machine.

iii. To determine the specimen with the highest ultimate strength.

1.4 PROBLEM STATEMENT

Composites usually used in high technology application because of their hardness and strength. However, fibre orientation in composite will affect the composite strength in which different build of orientation will be used. Stress distribution will be varied according to the orientation of fibre.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the importance and application of the composite materials at several sectors will be discussed. This chapter will inquired into the general properties of the components that commonly used to produce polymer composite materials which are fibre glass, polyester and epoxy. Through this chapter, the details of the composite materials can be understood in depth. The roles of build orientation in mechanical properties of the composite materials also can be studied deeply. Hence, a suitable composition of fibre and resin can be investigated to produce composite materials with better performance.

2.2 COMPOSITE

Practically everything is a composite material in some sense. For example, a common piece of metal is a composite (polycrystal) of many grains (or single crystals).
A composite material:

> Consists of two or more physically and/or chemically distinct, suitably arranged or distributed phases, with an interface separating them. It has characteristics that are not depicted by any of the components in isolation (D. Calllister William, 1985).

Most commonly, composite materials have a bulk phase, which is continuous, called the matrix, and one dispersed, non-continuous, phase called the reinforcement, which is usually harder and stronger.

The concept of composite materials is ancient: to combine different materials to produce a new material with performance unattainable by the individual constituents. An example is adding straw to mud for building stronger mud walls. Some more recent examples, but before engineered materials became prominent, are carbon black in rubber, steel rods in concrete, cement/asphalt mixed with sand, fibreglass in resin etc. In nature, examples abound: a coconut palm leaf, cellulose fibres in a lignin matrix (wood), collagen fibres in an apatite matrix (bone) etc.

The essence of the concept of composites is this: the bulk phase accepts the load over a large surface area, and transfers it to the reinforcement, which being stiffer, increases the strength of the composite. The significance here lies in that there are numerous matrix materials and as many fibre types, which can be combined in countless ways to produce just the desired properties.

Most research in engineered composite materials has been done since 1965. Today, given the most efficient design, of say an aerospace structure, a boat or a motor, we can make a composite material that meets or exceeds the performance requirements. Most of the savings are in weight and cost. These are measured in terms of ratios such as stiffness/weight, strength/weight, etc.

2.2.1 Definition of composite materials

The definition of a composite depends on the context. Composites are materials that utilize the combination of its constituents to increase a desired performance characteristic. Using this definition, the pearlitic steels may be thought of as a composite material formed by the combination of ferrite and cementite phases in alternating lamellae. The hard, brittle cementite combines with the soft, ductile ferrite to form a composite that has reasonably high strength along with some ductility. The present discussion will not focus on these naturally occurring composites, but rather those that are man made. These have phases that are chemically dissimilar and have a definite interface. Composites such as these have been developed to improve the strength, stiffness, and toughness of available materials.

A composite material may consist of many materials put together in many different ways. A simple example is material consisting of two phases. The matrix phase is continuous and forms the shape in which the dispersed phase acts as a constituent. There are different types of dispersed phase. It can be of a particle nature, meaning each particle is equiaxed, or it can be of a fibrous nature, where the dispersed phase is a filament. The type of dispersed phase, its orientation (for the fibrous type), size, relative amounts, and material properties will all affect the properties of the overall material.

2.2.2 Classification of composite types

Composite are classified by the geometry of the reinforcement

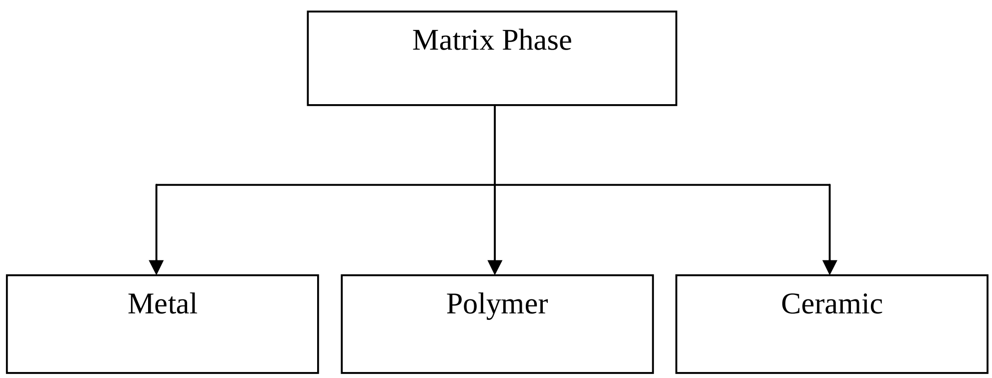

Figure 2.1: Matrix phase

The matrix phase is an essential part of the composite composition. Matrix materials can consist of a metal, polymer or a ceramic. Polymer matrices are the most common followed by metal and ceramics. The matrix phase has several important functions with respect to fibreous reinforced composites. The matrix acts to hold all reinforcements together thereby allowing the applied force to transmit to the reinforcement (L. Lehman Richard, 1999).

The matrix, due to its inherent ductility, does not carry a significant portion of the applied load. Instead the load is transmitted to the fibres. In order for this to occur the composite constituents must have a high fibre to matrix strength ratio. This can be seen in Figure 2 below.

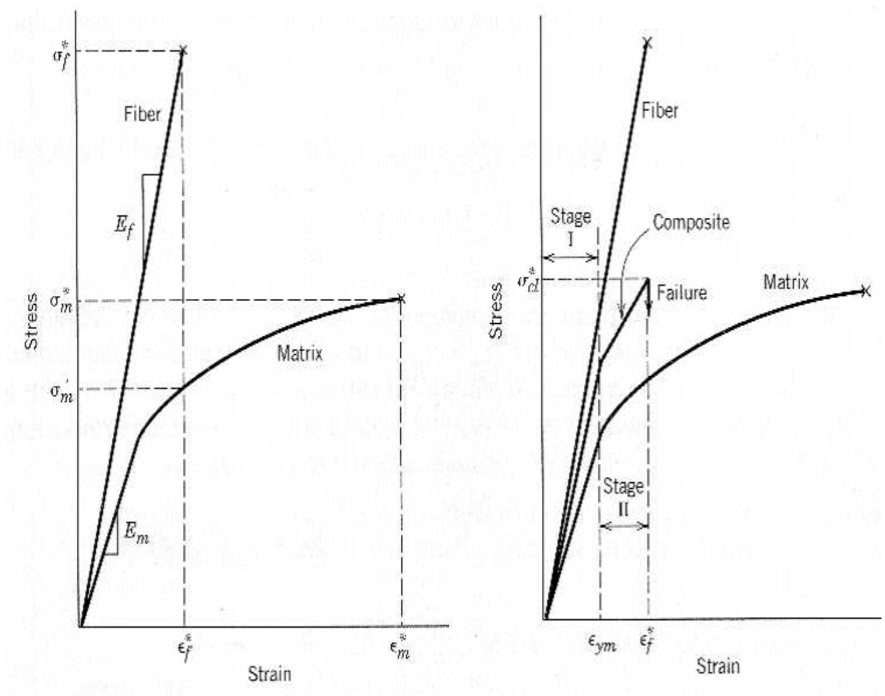

Figure 2.2: Stress –Strain curves of composite constituents

Other functions of the matrix include protection of the composite fibres from damage and to prevent crack propagation within the material. Adhesive bonding forces between the fibres and the matrix are essential in preventing separation of the two materials. This separation of the fibre from the matrix is called “pull-out”. The bonding force between the two phases must be large to prevent this from occurring. Bonding forces play an important role in the overall load carrying characteristics of the material.

2.3 POLYMER-MATRIX COMPOSITES (PMCs)

i. Matrix made from a polymer resin
ii. Fibres act as reinforcement mechanism
iii. Most widely used of all composites
iv. Low cost / Easily manufactured

Polymer-matrix composites (PMCs) can be grouped in three different categories. The grouping is based to a large degree on the type of fibre reinforcement utilized in the composite matrix. A variety of polymers may be used for each type of PMC. The three groups are glass fibre-reinforced polymer (GFRP), carbon fibre-reinforced polymer (CFRP), and aramid fibre-reinforced polymer composites (Peter Morgan, 2005). This grouping is shown in Figure 3.

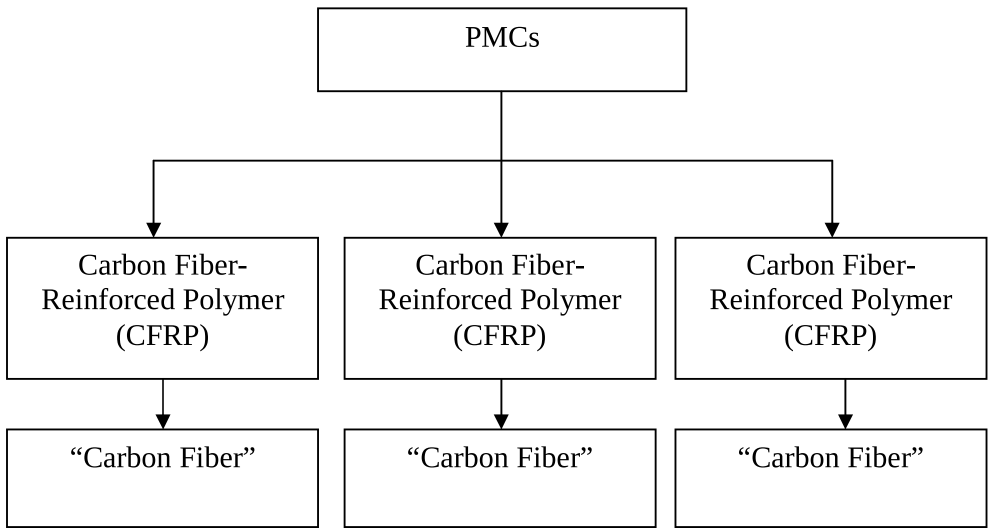

Figure 2.3: Grouping of polymer-matrix composites

2.4 GLASS FIBRE-REINFORCED POLYMER COMPOSITES (GFRP)

Glass fibre-reinforced polymer composites (GFRP), commonly known as fibreglass composites are the most widely used of all composites. GFRP is fibre-reinforced plastic made of a plastic reinforced by fine fibres made of glass . The plastic is thermosetting, most often polyester or vinylester, but other plastics, like epoxy (GRE), are also used.

2.4.1 Applications

GFRP is an immensely versitile material which combines lightweight with inherent strength to provide a weather resistant finish, with a variety of surface texture and an unlimited colour range available (Loewenstein, 1973).

GFRP was developed in the UK during the Second World War as a replacement for the molded plywood used in aircraft radomes (GFRP being transparent to microwaves). Its first main civilian application was for building of boats, where it gained acceptance in the 1950s. Its use has broadened to the automotive and sport equipment sectors, although its use there is being taken over by carbon fibre which weighs less per given volume and is stronger both by volume and by weight. GFRP uses also include hot tubs, pipes for drinking water and sewers, office plant display containers and flat roof systems.

Advanced manufacturing techniques such as pre-pregs and fibre rovings extend the applications and the tensile strength possible with fibre-reinforced plastics.

GFRP is also used in the telecommunications industry for shrouding the visual appearance of antennas, due to its RF permeability and low signal attenuation properties. It may also be used to shroud the visual appearance of other equipment where no signal permeability is required, such as equipment cabinets and steel support structures, due to the ease with which it can be molded, manufactured and painted to custom designs, to blend in with existing structures or brickwork. Other uses include sheet form made electrical insulators and other structural components commonly found in the power industries (Dominick V Rosato, 2004).

2.4.2 Physical properties

The properties of GFRP composites are measured the same way that traditional materials are measured so that comparisons can be made for evaluation. Typical measurements include:

Impact Strength –There are two primary impact tests; one is called IZOD impact and the other is called Charpy impact. IZOD impact measures the energy required to fracture or break a material when it is struck on its edge. Charpy impact measures the energy required to damage or puncture a material when it is struck on its front surface.

Tensile Strength– Measures how much of a load a material can take before it fractures or breaks when it is in the process of being stretched (Yunkai Lu, 2002).

2.5 FIBREGLASS

Fibreglass, (also called fibreglass and glass fibre), is material made from extremely fine fibres of glass. It is used as a reinforcing agent for many polymer products; the resulting composite material, properly known as fibre-reinforced plastic (FRP) or glassfibre-reinforced plastic (GFRP), is called "fibreglass" in popular usage. Glassmakers throughout history have experimented with glass fibres, but mass manufacture of fibreglass was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libbey exhibited a dress at the World's Columbian Exposition incorporating glass fibres with the diameter and texture of silk fibres. This was first worn by the popular stage actress of the time Georgia Cayvan.

What is commonly known as "fibreglass" today, however, was invented in 1938 by Russell Games Slayter of Owens-Corning as a material to be used as insulation. It is marketed under the trade name Fibreglas, which has become a genericized trademark. A somewhat similar, but more expensive technology used for applications requiring very high strength and low weight is the use of carbon fibre.